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(54) Fibrid reinforced elastomers.

(57) Polymeric fibrids reinforce elastomers to yield well-blended products of high modulus and elongation.

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Background of the Invention

The reinforcement of rubber and other elastomers with carbon black, p-aramid pulp and other materials is well known. See for example, U.S. 4,514,541 and 4,871,004. The use of fibrids in fibrid/elastomer compositions provides a simplified and more effective way of reinforcement over previously known fiber/elastomer compositions. The use of fibrids simplifies the mixing of the reinforcer and the elastomer, said mixing usually done in conventional "rubber" mixing equipment, such as Banbury, roll mill, extruder, etc. using well-known mixing techniques. Although these fibrids can be added as a masterbatch (pre-mixed with elastomers and/or other--usually solid--ingredients), in many cases they can be added even in the form of the "never-dried" product, i.e., containing substantial amounts of moisture. In case of rubber compositions which "set" due to chemical cross linking, this moisture is usually eliminated during the processing (mixing, calendering, molding) operations. With the thermoplastic elastomers this is not the case, and it is advisable to remove most or all of the moisture from the "never-dried" product prior to its addition to the elastomer.

Some of the prior art reinforced elastomeric products exhibit high modulus at low elongation but fail at high elongation. Other reinforcements present manufacturing problems because they are difficult to blend in with the elastomer and result in directional products. Poor blending is manifested by voids and flaws in the end product. Still other agents do not provide the desired degree of modulus improvement. The present invention seeks to overcome these deficiencies.

Summary of the Invention

This invention provides an elastomer composition reinforced with from 0.5 to 60 parts per hundred (phr), based on the weight of the elastomer, of polymeric fibrids. Preferably such fibrids are formed of poly(m-phenylene isophthalamide) (MPD-I) and still more preferably are "neverdried" MPD-I fibrids.

Detailed Description of the Invention

The reinforced elastomer compositions to which the present invention is directed, contain a major amount of the elastomer component which may be a natural or synthetic (including thermoplastics) rubber. In addition to the elastomer component, various conventional additives such as antioxidants, fillers, etc. are commonly included, for example:

"Hi-Sil" 233 - a precipitated hydrated amorphous silica reinforcing agent.

Paraflux - a polymerized saturated petroleum hydrocarbon plasticizer.

Agerite Resin D - An antioxidant. Polymerized 1,2-dihydro-2,2,4-trimethyl-1-quinoline.

Arofene Resin 8318 - A tackifier. Octylphenol formaldehyde, non-heat reactive.

N339 HAF carbon black reinforcing agent.

Cydac or Santocure - An accelerator, N-cyclohexyl-2-benzothiazole sulfenamide.

Crystex 20% Oiled Sulfur - A vulcanizer. Bloom retardant. Polymerized sulfur.

Santogard PVI (100%) - A retarder, N-(Cyclohexylthio) phthalimide.

Nochek 4607 - An antioxidant - Microcrystalline blend.

Flexone 3C - An antioxidant. N-isopropyl-N'phenyl-P-phenylene diamine.

Sundex 8125 - A plasticizer. Highly aromatic oil, ASTM D 2226, Type 101.

Elastomers used in the examples which follow are:

Neoprene FB - A low molecular weight polychloroprene suitable for use as vulcanizable plasticizer for neoprene and other synthetic elastomers.

Nordel^{R}1040 - A sulfur-curable, low viscosity hydrocarbon rubber, Ethylene-Propylene-Diene Polymethylene (EPDM).

SBR 1712 - Styrene butadiene rubber

RSS #1 - Natural rubber. Virgin rubber comprised of coagulated rubber sheets which have been properly dried and smoked.

Hytrel^{R} 4056 - Thermoplastic Polyester Elastomer.

The fibrids to be added may comprise any of those described in Morgan U.S. Patent No. 2,999,788 or others. Fibrids of MPD-I are particularly preferred when hydrolytic stability and resistance to degradation at elevated temperatures is required.

Unexpectedly high modulus has been observed in elastomeric compositions prepared by adding MPD-I fibrids which have not been dried to the elastomer batch. Such fibrids sometimes referred to as "never dried" are described in U.S. Patent No. 4,515,656. Those fibrids containing from about 30 to about 95% by wt. of water impart exceptionally high modulus to the elastomer and are preferred where this is the property most needed.

Fibrids containing little water provide elastomers of greater elongation but more limited modulus.

From about 1 to 30 phr of fibrids are normally combined with the elastomer, although as little as 0.5 phr will give an improvement in results.

In preparing the elastomer batch, the fibrids may be mixed in with the elastomer using conventional "rubber" mixing equipment, such as Banbury, roll mill, extruder, etc. using well-known mixing techniques. Although these fibrids can be added as a masterbatch (pre-mixed in proportions of about 100 to 500 phr fibrids with elastomers and/or other--usually solid--ingredients), in many cases they can be added even in the form of the "never-dried" products. In case of rubber compositions which "set" due to chemical cross linking, this moisture is usually eliminated during the processing (mixing, calendering, molding) operations. With thermoplastic elastomers this is not the case, and it is advisable to remove most or all of the moisture from the "never-dried" product prior to its addition to the elastomer.

The particulate elastomeric composition of the present invention is useful in the preparation of power transmission belts, rocket insulating liners, seals, packing, gaskets, tank treads, tires, conveyor belts, hoses, protective clothing (e.g. gloves), wheels and many other uses.

As compared to elastomers reinforced solely with carbon black, those of the present invention are markedly superior in modulus. As compared to poly(p-phenylene terephthalamide) pulp reinforced elastomers, those of the present invention are more readily blended with the elastomers and in general are superior with respect to elongation while exhibiting useful modulus.

Tests and Measurements

Physical properties are measured at room temperature on all samples. In all cases, at least 3 replicates per sample were run. Measurements are by the following methods:

Modulus (Stress/Strain): ASTM D-412-87 for cross-linked, chemically cured elastomers. ASTM-D-638-89 for thermoplastic elastomers.

Cut Growth Using Bead Area Endurance Test

This test is designed to assess the failure of passenger and truck tires due to pre-existing sidewall cuts while the tire is under load and speed.

The tire sidewall is cut in four equal spacings 1/2" in length, 1/16" deep, one each in the horizontal, vertical, left 45 degrees and right 45 degrees positions.

The tire is then subjected to the Bead Area Endurance test for maximum flex.

The tire is mounted on an appropriate heavy-duty test rim and conditioned at 100°F for 4 hours at 24 psi. The pressure is adjusted to the maximum psi allowed for the specific load range and then conditioned for another 4 hours.

The tire is then tested at 30 mph in the following sequence until failure: 90% rated load, 2 hours; 115% load, 2 hours; 150% load, 20 hours; 170% load, 20 hours; 190% load, 20 hours; and 210% load, until failure.

The following examples are illustrative of the invention (except for comparative examples or controls) and are not intended as limiting.

Example 1

985 grams of never-dried MPD-I fibrids (premeasured at 13% solids content to give equivalent weight of 128 grams dry-basis fibrids) were air dried overnight in an oven at 100°C. The dried fibrids were placed in an Eirich mixer with 128 grams of Hi-Sil 233 for two minutes, the mixer was shut down, the sides wiped and then run an additional two minutes. The 256 grams of mix was added to a Banbury mixer along with 512 grams of Nordel^{R} 1040, 128 grams of Neoprene FB, and 99 grams of Hi-Sil 233. The mixer was run until the temperature reached 93°C. The dry ingredients were then brushed down, and the mixer run until the temperature reached 116°C. The mixer is shut down and the elastomer mixture removed. The mixture is placed on a rollmill and the remaining dry ingredients (Table 1) added slowly. Milling was continued until these remaining dry ingredients were uniformly blended. The compounded rubber sheet was slit and removed from the roll, cut to size, and cured for 30 minutes at 160°C at 8,625 kPa.

A control was prepared in the Banbury using the same procedure and quantities above except no MPD-I fibrids were added.

A comparison composition was prepared using the same procedures and quantities above except 128 grams of poly(p-phenylene terephthalamide) (PPD-T) pulp were substituted for the fibrids in the Banbury.

Table 1

Formulations, grams

Ingredient	Control (no fibrid)	Comparison (20 phr pulp)	Example 1 (20 phr fibrids)
Nordel^{R} 1040	512	512	512
Neoprene FB	128	128	128
"Hi-Sil" 233	227	227	227
MPD-I fibrid	0	0	128
PPD-T pulp	0	128	0
Zinc Oxide	32	32	32
Sulfur	9.6	9.6	9.6
MBT (a)	6.4	6.4	6.4
Methyl Tuads (b)	3.2	3.2	3.2
Butyl Zimate (c)	12.8	12.8	12.8

(a) 2-mercaptobenzothiazole, accelerator

(b) tetramethylthiuram disulfide, accelerator

(c) zinc dibutyldithiocarbamate, accelerator

Results are shown in Table 2.

Table 2

Test	Control (no fibrid)		Comparison (pulp)		Example 1 (fibrids)	
	MD	CMD	MD	CMD	MD	CMD
Modulus, RT (1)						
10%	74	69	1576	279	450	265
20%	113	106	1699	373	612	351
30%	141	131	brk	448	708	405
50%	178	164	brk	576	799	487
100%	236	215	brk	803	820	01
Breaking Elongation %, RT	439	417	20	125	195	286

(1) RT is Room Temperature. Results shown as stress in psi at different % Elongation levels. Results are shown in the machine direction (MD) and cross machine direction (CMD).

Example 2

Never-dried MPD-I fibrids (premeasured at 13% solids) were opened using the forces of a turbulent air milling known as an Ultra-Rotor. Partial drying was achieved concurrently through the use of an attached, adjustable heat load drying section. The resulting milled fibrids were measured at 34% solids. 95 grams of these partially dried, ultra-rotored fibrids (32 grams fibrids dried weight basis) were combined with 32 grams of N-339

HAF Carbon Black in a tumble mixer for 7 minutes. The 127 grams of mix was added to a Banbury mixer along with all the ingredients in Table 3 except for the Cydac, Crystex, and Santogard. The Banbury was run using standard Banbury mixing techniques, not exceeding 149°C. The mix was dumped, cooled, and put through the Banbury again, now adding the Cydac, Crystex, and Santogard, again not exceeding 149°C. The mixer was shut down and the elastomer mixture removed. The mixture was milled on a roll mill using cooling water. The compounded rubber sheet was slit and removed from the roll, cut to size, and cured for 30 minutes at 160°C at 8,625 kPa.

A control was prepared in the Banbury using the same procedure and quantities above except no fibrids were added.

A comparison composition was prepared using the same procedures and quantities above except 32 grams of PPD-T pulp were substituted for the MPD-I fibrids in the Banbury.

Table 3

Formulations, grams

Ingredient	Control (no fibrid)	Comparison (5 phr pulp)	Example 2 (5 phr fibrid)
RSS #1	640	640	640
Stearic Acid	12.8	12.8	12.8
Zinc Oxide	32	32	32
MPD-I fibrid	0	0	32
PPD-T pulp	0	32	0
N-339 HAF Carbon Black	352	352	352
Paraflux	32	32	32
Agerite Resin D	6.4	6.4	6.4
Arofene Resin 8318	19.2	19.2	19.2
Cydac or Santocure	4.48	4.48	4.48
Crystex 20% Oiled Sulfur	20.03	20.03	20.03
Santogard PVI (100%)	1.92	1.92	1.92

Results are shown in Table 4

Table 4

Test	Control (no fibrid)		Comparison (5 phr pulp)		Example 2 (5 phr fibrid)	
	MD	CMD	MD	CMD	MD	CMD
Modulus, RT (1)						
10%	114	117	907	175	443	190
20%	160	165	1145	245	606	262
30%	191	200	1176	298	704	322
50%	247	266	1156	391	816	430
100%	438	489	1168	659	1049	728
Breaking Elongation %, RT	485	427	348	319	317	262

(1) RT is Room Temperature. Results shown as stress in psi at different % Elongation levels.

Example 3

A quantity of never-dried MPD-I fibrids (premeasured at 13% solids content) were opened using the forces of a turbulent air milling known as an Ultra-rotor. Partial drying was achieved concurrently through the use of an attached, adjustable heat load drying section. The resulting milled fibrids were measured at 55% solids. 233 grams of this partially dried, ultra-rotored fibrids (128 grams fibrids dried weight basis) were combined with 128 grams of Hi-Sil 233 and tumble mixed for 5 minutes. The 361 grams of mix was added to a Banbury mixer along with 512 grams of Nordel^{R} 1040, 128 grams of Neoprene FB, and 99 grams of Hi-Sil 233. The mixer is run using standard Banbury mixing techniques until the temperature reaches 93°C. The mixer is shut down, dry ingredients brushed down, restarted and ran until the temperature reaches 116°C. The mixer is shut down and the elastomer mixture removed. The mixture is placed on a roll mill and the remaining dry ingredients (Table 5) added slowly. Milling is continued until these remaining dry ingredients are uniformly blended. The compounded rubber sheet is slit and removed from the roll, cut to size, and cured for 30 minutes at 160°C at 8,625 kPa.

A control was prepared in the Banbury using the same procedure and quantities above except no fibrids were added.

Table 5

Formulations, grams

Ingredient	Control (no fibrid)	Example 3 20 phr fibrid
Nordel^{R} 1040	512	512
Neoprene FB	128	128
"Hi-Sil" 233	227	227
MPD-I fibrid	0	128
Zinc Oxide	32	32
Sulfur	9.6	9.6
MBT	6.4	6.4
Methyl Tuads	3.2	3.2
Butyl Zimate	12.8	12.8

Results are shown in Table 6.

Table 6

Test	Control (no fibrid)		Example 3 (fibrids)	
	MD	CMD	MD	CMD
Modulus, RT (1)				
10%	74	69	1031	357
20%	113	106	1153	450
30%	141	131	brk	512
50%	178	164	brk	590
100%	236	215	brk	brk
Breaking Elongation %, RT	439	417	21	85

(1) RT is Room Temperature. Results shown as stress in psi at different % Elongation levels. brk indicates sample has broken before reaching this point.

Example 4

Never-dried MPD-I (premeasured at 13% solids) were opened using the forces of a turbulent air milling known as an Ultra-Rotor. Partial drying was achieved concurrently through the use of an attached, adjustable heat load drying section. The resulting milled fibrids were measured at 67% solids. 48 grams of these partially dried, ultra-rotored fibrids (32 grams fibrids dried weight basis) were combined with 32 grams of N-339 HAF Carbon Black in a tumble mixer for 7 minutes. The 80 grams of mix was added to a Banbury mixer along with all the ingredients in Table 7 except for the Cydac, Crystex, and Santogard. The Banbury is run using standard Banbury mixing techniques, not exceeding 149°C. The mix is dumped, cooled, and run through the Banbury again, now adding the Cydac, Crystex, and Santogard again not exceeding 149°C. The mixer is shut down and the elastomer mixture removed. The mixture is milled on a roll mill using cooling water. The compounded rubber sheet is slit and removed from the roll, cut to size, and cured for 30 minutes at 160°C at 8,625 kPa.

A control was prepared in the Banbury using the same procedure and quantities above except no fibrids were added.

Table 7

Formulations, grams

Ingredient	Control (no fibrid)	Example 4 (5 phr fibrid)
RSS #1	640	640
Stearic Acid	12.8	12.8
Zinc Oxide	32	32
MPD-I fibrid	0	32
N-339 HAF Carbon Black	352	352
Paraflux	32	32
Agerite Resin D	6.4	6.4
Arofene Resin 8318	19.2	19.2
Cydac or Santocure	4.48	4.48
Crystex 20% Oiled Sulfur	20.03	20.03
Santogard PVI (100%)	1.92	1.92

Results are shown in Table 8.

Table 8

Test	Control (no fibrid)		Example 4 (5 phr fibrid)	
	MD	CMD	MD	CMD
Modulus RT (1)				
10%	114	117	194	144
20%	160	165	293	207
30%	191	200	364	255
50%	247	266	469	348
100%	438	489	681	616
Breaking Elongation %, RT	485	427	377	305

(1) RT is Room Temperature. Results shown as stress in psi at different % Elongation levels.

Example 5

A quantity of never-dried MPD-I fibrids (premeasured at 13% solids content) were opened using an Ultra-

rotor. Partial drying was achieved concurrently through the use of an attached, adjustable heat load drying section. The resulting milled fibrids were measured at 93% solids. 69 grams of this partially dried, ultra-rotored fibrids (64 grams fibrids dried weight basis) were combined with 64 grams of PPD-T pulp and with 128 grams Hi-Sil 233 and tumble mixed for 5 minutes. The 261 grams of mix was added to a Banbury mixer along with 512 grams of Nordel^{R}1040, 128 grams of Neoprene FB, and 99 grams of Hi-Sil 233. The mixer is run using standard Banbury mixing techniques until the temperature reaches 93°C. The mixer is shut down, dry ingredients brushed down, restarted and ran until the temperature reaches 116°C. The mixer is shut down and the elastomer mixture removed. The mixture is placed on a roll mill and the remaining dry ingredients (Table 9) added slowly. Milling is continued until these remaining dry ingredients are uniformly blended. The compounded rubber sheet is slit and removed from the roll, cut to size, and cured for 30 minutes at 160°C at 8,625 kPa.

A control was prepared in the Banbury using the same procedure and quantities above except no fibrids were added.

A comparison composition based on PPD-T pulp was prepared using the same procedures and quantities above except 128 grams of pulp were substituted for the fibrids and pulp in the Banbury.

Table 9

Formulations, grams

Ingredient	Control (no fibrid)	Comparison (20 phr pulp)	Example 5 (10 phr fibrid/10 phr pulp)
Nordel^{R} 1040	512	512	512
Neoprene FB	128	128	128
"Hi-Sil" 233	227	227	227
MPD-I fibrid	0	0	64
PPD-T pulp	0	128	64
Zinc Oxide	32	32	32
Sulfur	9.6	9.6	9.6
MBT	6.4	6.4	6.4
Methyl Tuads	3.2	3.2	3.2
Butyl Zimate	12.8	12.8	12.8

The results are shown in Table 10.

Table 10

Test	Control (no fibrid)		Comparison (20 phr pulp)		Example 5 (10 phr fibrid/10 phr pulp)	
	MD	CMD	MD	CMD	MD	CMD
Modulus RT (1)						
10%	74	69	1576	279	1508	316
20%	113	106	1699	373	brk	410
30%	141	131	brk	448	brk	481
50%	178	164	brk	576	brk	586
100%	236	215	brk	803	brk	731
Breaking Elongation %, RT	439	417	20	125	13	109

(1) RT is Room Temperature. Results shown as stress in psi at different % Elongation levels.

EXAMPLE 6

1600 grams of never-dried polyacrylonitrile fibrids (8% solids, yielding equivalent dry weight of 128 grams fibrids) were combined with 227 grams of "Hi-Sil" 233 in an Eirich mixer ran for two minutes to mix and open the mixture. The mixer was shut down, the sides wiped down of any material, ran for an additional two minutes, and the mixture removed. The mixture was air-dried overnight in an oven at 100°C. The dry mix was placed in an Eirich mixer and ran for two minutes. The mix was removed, yielding 355 grams. This dry mix was added to a Banbury mixer with 512 grams of Nordel^{R} 1040, and 128 grams of Neoprene FB. The mixer is run using standard Banbury techniques until the temperature reaches 93°C. The mixer is shut down and dry ingredients are brushed down. The mixer is closed, restarted, and run until the temperature reaches 116°C when the mixer is shut down and the mixture removed. This mixture is placed on a roll mill, remaining dry ingredients (Table 11) added slowly, and milling continued until the dry ingredients are uniformly mixed. The compounded rubber slab is slit, cut, and cured for 30 minutes at 160°C at 8,625 kPa.

Table 11

Formulation, grams

Ingredient	Example 6 (20 phr fibrid)
Nordel^{R} 1040	512
Neoprene FB	128
Acrylic fibrids	128
"Hi-Sil" 233	227
Zinc Oxide	32
Sulfur	9.6
MBT	6.4
Methyl Tuads	3.2
Butyl Zimate	12.8

Results are shown in Table 12.

Table 12

Test	Example 6 (20 phr fibrids) MD	CMD
Modulus, RT (1)		
10%	443	264
20%	617	356
50%	808	516
100%	873	652
Breaking Elongation, RT, %	206	289

(1) RT is Room Temperature. Results are shown as stress in psi at different % Elongation levels.

EXAMPLE 7

The formulation shown in Table 13 was used in combining the Natural Rubber, SBR 1712, never-dried MPD-I fibrids (about 90% water) Zinc Oxide, Stearic Acid, and the HAF Carbon Black in a Banbury mixer. Following standard Banbury mixing techniques, the elastomer is dropped onto the roll mill where the remaining dry ingredients (Table 13) are added and milling continued to achieve uniform mixing. The compounded sheet is cured at 149°C for 30 minutes from which samples are cut for lab analysis.

The control was prepared using the same formulation and procedures but with no reinforcing fibrid.

Table 13
Formulations, phr

Ingredient	Control (no fibrid)	Example 7 (5 phr fibrid)
RSS #1	40	40
SBR 1712	82.5	82.5
MPD-I fibrid	0	5
Zinc Oxide	3.7	3.7
Stearic Acid	2.5	2.5
HAF Black	43.5	43.5
Sundex 8125	2.4	2.4
Flexzone 3C	3.0	3.0
Nochek 4607	2.7	2.7
Santocure	0.95	0.95
Crystex 20% Oiled Sulfur	2.6	2.6
	183.85	188.85

Results are shown in Table 14.

Table 14

Test	Control (No fibrid)	Example 7 (5 phr fibrid)
Modulus, RT (1)		
100%	--	330
200%	--	590
300%	887	1034
Breaking Elongation, RT, %	594	426
Tire Cut Growth		
Miles to failure	2815	2362
Load % at failure	210	210

(1) RT is Room Temperature. The results are shown as stress in psi at different % Elongation levels. Results are shown in the machine direction (MD). -- indicates samples not measured at this level.

Example 8

A quantity of never-dried MPD-I fibrids were opened using an Ultra-rotor and partially dried as described in Example 5 to 93% solids. These fibrids were then further dried overnight at 100°C. These dried fibrids were

then mixed with powdered Hytrel® 4056 polyester thermoplastic elastomer in a tumble mixer with a resulting concentration of 3% MPD-I fibrids. This material was dried overnight in a 70°C oven with Nitrogen purge. The mix was removed from the oven and immediately fed to the screw extruder using standard extruder conditions. The extruded elastomer is water quenched and chopped into pellets. The pellets are then molded for testing using standard molding techniques and conditions. The test specimens are direct molded or die-cut from sheets. The results are shown in Table 15.

Table 15

		Control (no fibrid)	Example 8 (3% fibrid)
Modulus, RT (1)			
25%,	molded	960	1185
	die-cut	929	1198
100%,	molded	986	1297
	die-cut	1068	1375

(1) RT is Room Temperature. The results are shown as stress in psi at different % Elongation levels. Results are shown in the machine direction (MD).

Claims

1. An elastomer composition reinforced with from 0.5 to 60 parts of polymer fibrids per hundred parts of the elastomer.

2. An elastomer composition according to claim 1 wherein the fibrids are from poly(m-phenylene isophthalamide).

3. An elastomer composition according to claim 2 containing poly(p-phenylene terephthalamide) pulp in addition to the fibrids.

4. An elastomer composition according to any one of claims 1 to 4 wherein the fibrids are from polyacrylonitrile.

5. An elastomer composition according to any one of claims 1 to 4 wherein the elastomer is natural rubber.

6. An elastomer composition according to claim 1 wherein the elastomer is synthetic rubber.

7. A process for preparing an elastomer composition comprising incorporating from 0.5 to 60 parts of fibrids per hundred parts of the elastomer.

8. A process according to claim 7 wherein the fibrids are from poly(m-phenylene isophthalamide).

9. A process according to claim 8 wherein the fibrids are never-dried poly(m-phenylene isopthalamide).

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EUROPEAN SEARCH REPORT

Application Number
EP 91 31 1643

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	US-A-4 309 531 (J.KYRITSOS ET AL.) * abstract, especially four last lines *	1	C08J5/04 C08L21/00
X	EP-A-0 142 795 (BASF AKTIENGESELLSCHAFT) * abstract *	1	
D,X	US-A-2 999 788 (P.W.MORGAN) * column 55, line 4 * * example 11 *	1,4	
D,A	US-A-4 514 541 (A.FRANCES) * abstract * * column 2, line 20 - line 26 *	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

C08J
C08L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	30 SEPTEMBER 1992	VAN HUMBEECK F.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
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